

FIG. 2 is a chart showing various performance characteristics of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

The following description includes the preferred best mode of one embodiment of the present invention. It will be clear from this description of the invention that the invention is not limited to these illustrated embodiments but that the invention also includes a variety of modifications and embodiments thereto. Therefore the present description should be seen as illustrative and not limiting. While the invention is susceptible of various modifications and alternative constructions, it should be understood, that there is no intention to limit the invention to the specific form disclosed, but, on the contrary, the invention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention as defined in the claims.

FIGS. 1-3 show a variety of embodiments and features of the present invention. In these embodiments Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coatings on 441 ferritic stainless steel are shown and described. While this specific example is shown it is to be distinctly understood that the present invention is not limited thereto but maybe variously alternatively configured according to the needs and necessities of a user

Ferritic stainless steels appear to be a promising alloys for SOFC interconnect applications. AISI 441 stainless steel, which contains ~18% Cr and minor alloying additions including Nb and Ti, is a good example of a low cost candidate interconnect steel. To provide satisfactory performance however, the alloy in this configuration needs cathode-side protection, such as a  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  protection layer to block Cr ion outward diffusion and to mitigate oxygen ion inward diffusion. In addition, since this alloy does not contain reactive elements, the scale adhesion requires further improvement as well. As shown in FIG. 1(a), SEM observation on the cross section of a prior art sample that was tested at 850° C. in air for 1,000 hours found detachment of the scale (grown beneath the protection layer) from the metal substrate. This detachment, which could have occurred either during polishing or the final cooling of the test, indicates poor scale/alloy adhesion.

The present invention provides improved scale adhesion in such materials. In one embodiment this was demonstrated by spinel coatings prepared by slurry coating the alloy with a Ce-containing composition having the nominal formula of  $\text{Mn}_{1.475}\text{Co}_{1.475}\text{Ce}_{0.05}\text{O}_4$ . After testing under identical conditions and subsection to identical post-test sample preparation as for the prior art sample described earlier (non-Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coated 441), the Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coatings on 441 were found to be well adherent to the metal substrate (see FIG. 1(b)).

The enlarged images (see FIGS. 1(a) and (b)) show that the scale beneath the  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coating tended to grow with a smooth interface with the metal substrate, while the scale beneath the Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coating grew with a rougher interface with the metal substrate. It appears that presence of Ce in the coating altered the scale growth and interfacial structure and properties, resulting in improved scale/alloy interfacial bonding. Similar behavior was observed on samples that were tested at 800° C. for 1,000 hours in air.

In addition to the positive effects on the interfacial structure and properties, the presence of Ce had no undesirable effect on electrical resistance. In fact, as shown in the chart in FIG. 2, a 441 sample with a Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  protection layer demonstrated stable area-specific electrical resistance that was actually slightly lower than that of 441 with a non-Ce-containing  $\text{Mn}_{1.5}\text{Co}_{1.5}\text{O}_4$  coating.

While various preferred embodiments of the invention are shown and described, it is to be distinctly understood that this invention is not limited thereto but may be variously embodied to practice within the scope of the following claims. From the foregoing description, it will be apparent that various changes may be made without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A coating for fuel cell interconnect systems characterized by:
  - a. a substrate alloy of a SOFC metallic interconnect; and
  - b. a single protection layer on the alloy, wherein the protection layer includes a rare earth element-containing Mn—Co spinel oxide, and wherein the adhesion between an oxide scale and the alloy is increased by the presence of the rare-earth element in the protection layer relative to a protection layer that does not contain a rare earth element.
2. The coating of claim 1 wherein the rare earth element is Cerium.
3. The coating of claim 1 wherein the protection layer includes between 0.01-5% of said rare earth element(s).
4. The coating of claim 3 wherein said rare earth element is Cerium.
5. An interconnect for fuel cells characterized by a single layer coating on the interconnect, wherein the single layer coating includes a rare earth element-containing Mn—Co spinel oxide, wherein the adhesion between an oxide scale and an alloy substrate of the interconnect is increased by the presence of the rare-earth element in the coating relative to an oxide coating that does not contain a rare earth element.
6. The interconnect of claim 5 wherein said rare earth element is Ce.
7. The interconnect of claim 5 wherein said oxide includes between 0.01-5% of said rare earth element(s).
8. The interconnect of claim 7 wherein said rare earth element is Ce.
9. The interconnect of claim 5 wherein said coating overlies a ferritic stainless steel.
10. A method of improving scale adhesion to a substrate alloy for a SOFC interconnect characterized by:
  - coating the alloy with a protection layer containing a rare earth element-containing Mn—Co spinel oxide; and
  - increasing the scale adhesion between an oxide scale and the alloy by the presence of the rare earth element in the protection layer relative to a protection layer that does not contain a rare earth element.
11. The method of claim 10 wherein the rare earth element is Cerium.
12. The method of claim 10 wherein the oxide includes between 0.01-5% of the rare earth element(s).

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